EFFECTS OF ACUTE AND CHRONIC EXERCISE ON AGILITY SKILLS

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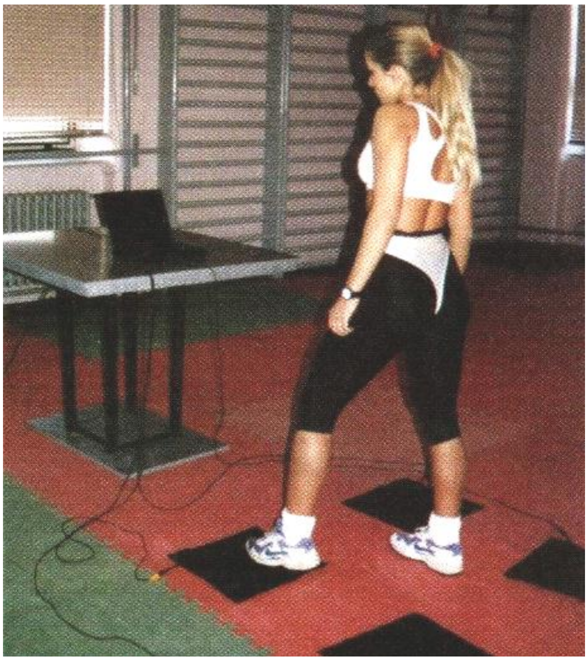
Introduction

While effects of exercise induced fatigue on reaction time have been widely investigated, less attention has been paid to acute and adaptive changes in agility time. Here, our findings on the effect of acute and chronic exercise on agility skills in various populations will be presented.

To measure agility time, subjects are instructed to use either the left or right lower limb to make contact with one of the four mats located in four corners outside of a pre-defined square (Figure 1a). They are encouraged to execute leg movements as quickly as possible and to touch the mats in accordance with the location of the stimulus in one of the corners of the screen. The results is total agility time and agility time in each movement direction (Figure 1b).



MOVEMENT DIRECTION	N (#)	BEST (ms)	WORST (ms)	AVERAGE (ms)	SD (ms)
rear left	15	511	1236	654,3	175,5
rear right	15	497	1197	665,8	206,0
front left	15	486	1336	586,9	203,7
front right	15	432	1267	609,8	188,3
** TOTAL **	60	432	1336	629,2	196,4

Figure 1 (a) Reactive Agility Test and (b) an example of results (FiTRONiC, SVK)

Reaction tasks performing while standing on unstable surfaces

One of our former studies investigated the reaction time and sway velocity while responding to visual stimuli concurrently with balancing on a wobble board (Zemková et al., 2009c). A group of physically active individuals was asked to respond to either one or two randomly generated visual stimuli while standing on an unstable support surface for a period of 3 minutes. During the task execution, both sway velocity and reaction time were registered. A differential course of simple and two-choice reaction times was identified. There were no significant changes in simple reaction time while balancing on a wobble board, whereas two-choice reaction time significantly increased from an initial 5-second to the final 5-second period of the test. On the other hand, the CoP velocity gradually decreased during a simple reaction task. When responding to two stimuli, there was a significant decrease in CoP velocity for an initial 2:15 minutes, followed by a slight increase toward the end of the test. Interestingly, two-choice reaction task resulted in greater balance improvement compared to simple reactions. In summary, reaction time increases while balancing on an unstable support surface, whereas sway velocity declines when concurrently performing reaction tasks.

The following study evaluated the effect of 8-week instability training while concurrently responding to visual stimuli on CoP velocity and reaction time (Zemková et al., 2009a). A group of recreationally active individuals was divided into the experimental group 1 and the experimental group 2. They underwent reaction tasks similar to game-like situations in floorball either on wobble boards or a stable support base (one 30 minutes session a week). The CoP velocity registered under unstable conditions as a parameter of dynamic balance significantly decreased in the experimental group 1. Its greater reduction was recorded when responding to visual stimuli concurrently with balancing on a wobble board. Multi-choice reaction time measured under unstable conditions also decreased significantly. However, this effect was not observed when standing on a stable support base. Similarly, there were no significant changes in the CoP velocity registered in static conditions. These findings indicate that balance exercises performed simultaneously with reaction tasks represent an effective means for reduction of multi-choice reaction time and improvement of dynamic balance, namely when responding to visual stimuli.

Post-exercise reaction and agility time responses to exercise

A warm-up in the form of exercise of moderate intensity was shown to contribute to faster responses to visual stimuli, whereas fatigue induced by a high intensity exercise is associated with an increase in reaction time (Zemková et al., 2009b). More specifically, there is an exponential character between reaction time and heart rate during exercise, i.e. reaction time slightly decreases with exercise intensity below the aerobic threshold followed by a plateau, and then gradually increases after reaching an approximate anaerobic threshold up to exhaustion. However, the effect of exercise intensity above approximately 160 bpm depends also on stimulus-response compatibility, i.e. there is a steeper increase in reaction time when responding to laterally discordant than concordant stimuli.

Similarly, investigating post-exercise changes in agility time revealed that its values decrease significantly after exercise of moderate intensity (Zemková et al., 1998b; Zemková, 2003). On the other hand, agility time increases significantly after a high intensity exercise, somewhat above anaerobic threshold. This indicates that post-exercise agility performance depends on the type of fatigue, i.e. it improves after exercise of moderate intensity but is negatively affected by highly intensive exercise.

With regards to sport specific exercise, agility time increases after the first half of a soccer match when traveling shorter distance of 0.8 m (Zemková, Hamar, 2009). Its values increase also after the second half of a soccer match, however when traveling longer distance of 1.5 m. It means that a soccer match induced fatigue affects agility skills when traveling either on shorter or longer distances depending on the level of fatigue.

Pre-post training changes in reaction and agility time

Previous study evaluated the effect of 6-week high intensity agility training (3-times a week for 30 minutes) on simple and multi-choice reaction and agility times in karate competitors (Miklovič, Zemková, 2012). Both simple and multi-choice agility time decreased significantly after the training. In the first case, a substantial part of the improvement occurred during the initial 0–40 seconds and the final 161–200 seconds of the test, whereas in the second case, improvements occurred during the middle period, from 41 to 160 seconds. However, there were no significant changes in simple and multi-choice reaction times. Improvement of agility skills may be attributed to the specificity of the training applied. Nevertheless, it seems that the training was not sufficient to improve the perception and decision stage of this task. Thus, more specific exercises should be implemented in the training program for reduction of reaction time.

The next study evaluated the effect of 6-week combined reactive-balance training (4–5 sessions a week in duration of 30 minutes each) on neuromuscular performance in basketball players (Zemková, Hamar, 2010). They were divided into the experimental group 1 and the experimental group 2, and performed reaction tasks similar to game-like situations either on wobble boards or a stable support base. The training in the experimental group 1 increased acceleration of running that most likely contributed to shorter agility time, decreased CoP velocity under dynamic conditions, reduced ground contact time during drop jump, and improved the ability to differentiate the intensity of muscle contraction during repeated jumps. However, such training was insufficient to improve static balance, simple and two-choice reaction times, and jump performance. On the other hand, the experimental group 2 failed to show any significant improvement in these abilities except for the enhancement of jump performance. These findings indicate that balance exercises performed simultaneously with reaction tasks represent an effective means for the improvement of neuromuscular performance in elite athletes. Also of interest was the additional finding that the improvement in agility skills in older players (on average 21 years) was greater than in their younger, less experienced counterparts (on average 15 years). This may be attributed to faster feedback control of movement execution, i.e. as experience level increased with practice, the movement time decreased.

Another study showed significantly shorter agility time following 6 weeks of training focused on the improvement of agility skills in volleyball players (Luknárová, Zemková, 1998; Zemková et al., 1998a). However, there were no significant changes in agility time after the same period of volleyball training. This indicates that specific agility exercises should be applied for highly-skilled athletes in order to improve their agility skills.

Furthermore, volleyball players exhibited a significant improvement in agility time following one year of training (Luknárová et al., 1998). More specifically, agility time significantly improved after specific agility training in the middle of the competition period. However, there were no significant changes in agility time after summer athletic training. This reflects their actual ranking during different training periods.

Besides athletes, agility is also a skill required by the general population, including the elderly. In addition to balance or resistance exercises, whole body vibration can be used for improvement of their neuromuscular functions. We have evaluated the effect of 3-month serial mechanical proprioceptive stimulation training (3 times a week) on agility, balance and strength in older women. They were randomly divided into two experimental groups. While an experimental group 1 performed semi-squats (6 sets of 10 repetitions without and with an additional load of 20% of body weight, separated by 2 minutes of a rest), the experimental group 2 stood in a semi-squat position on a vibration platform (6 sets of 30 and 45 seconds, separated by 2 minutes of rest). Proprioceptive stimuli were applied by means of a platform producing short-term counter shocks (ground reaction force increases of about 1 G within 3 ms at the frequency of 10 Hz). Regarding agility skills, both training regimens led to their improvements (Zemková et al., 2004; Zemková et al., 2006). However, this effect was more evident in subjects performing semi-squats rather than in those standing in semi-squat position on a vibration platform. On the other hand, the control group failed to show any significant reduction in agility time. It seems obvious that serial mechanical proprioceptive stimulation applied to the lower limbs improves agility skills in older women. Such positive changes may be ascribed to the improvement of neuroregulatory functions, namely an increased rate of motoneuron firing and better synchronisation of motor unit activation.

Conclusions

This study provided an overview of our findings on effects of acute and chronic exercise on agility skills in various populations.

i) Reaction time increases while balancing on an unstable support surface, whereas sway velocity declines when concurrently performing reaction tasks.

ii) A 8-week training that includes balance exercises performed simultaneously with reaction tasks reduces multi-choice reaction time and improves dynamic balance, namely when responding to visual stimuli.

iii) A warm-up in the form of exercise of moderate intensity contributes to faster responses to visual stimuli, whereas fatigue induced by a high intensity exercise is associated with an increase in reaction time.

iv) Also post-exercise agility time depends on the type of fatigue; it decreases after exercise of moderate intensity but increases after highly intensive exercise.

v) A soccer match induced fatigue affects agility skills when traveling either on shorter or longer distances depending on the level of fatigue.

vi) A 6-week high intensity agility training decreases both simple and multi-choice agility time in karate competitors, however it is not sufficient to reduce simple and multi-choice reaction time.

vii) A 6-week combined reactive-balance training consisting of balance exercises performed simultaneously with reaction tasks decreases simple and two-choice agility time in basketball players, most likely due to faster acceleration of running, whereas it is insufficient to reduce simple and two-choice reaction time.

viii) A 6-week training focused on the improvement of agility skills reduces agility time in volleyball players, whereas its values do not change after the same period of volleyball training.

ix) Volleyball players improves agility skills also following one year of training while reflecting their actual ranking during different training periods. The agility time decreases after specific agility training in the middle of the competition period but do not change after general athletic training.

x) A 3-month serial mechanical proprioceptive stimulation training improves agility skills in older women. However, this efect is more evident when they perform semi-squats rather than stay in a semi-squat position on the platform producing proprioceptive stimuli in a form of short-term counter shocks to the lower extremities.

More information regarding these experimental studies can be found in a book entitled *"Toward an understanding of agility performance"* (Zemková, Hamar, 2015).

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